Beginning January 1, 1981, DWR estimates of crop water use were based upon evaporation observed at Bakersfield 10NW. Data from that station were used until May 1990, when the record was shifted to the average of the Bakersfield 12S and Lamont 2NW agroclimatic stations (see Figure 1). The average of observed evaporation for those two locations continued to be used through 1991.

Corrections for Periods of High Evaporation

For periods of high wind or very high or low relative humidity, observed evaporation was corrected to compensate for the different response of plant transpiration and evaporation from the pan water surface. The correction factors used are listed below.

Evaporation Corrections[1]

Wind Movement Miles Per Day	Mean Relative Humidity – Percent		
	<40	40 – 70	>70
0 – 100	0.88	1.00	--
100 – 200	0.83	0.96	1.00
200 – 300	0.79	0.89	0.96

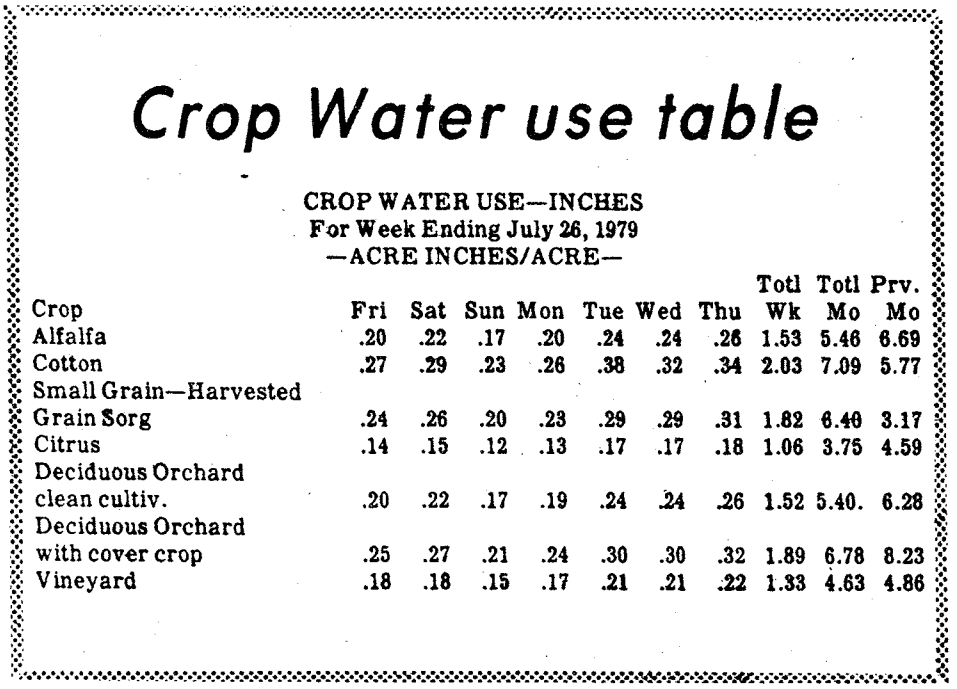
[1]Adapted from Table 19, United Nations Food and Agriculture Organization Irrigation and Drainage paper No. 24, *Crop Water Requirements*, United Nations, Rome, 1977, p 55.

It was necessary to use evaporation corrections only once or twice each year.

Calculated Crop Water Use

From January 1977 through December 1985, crop water use was calculated for each day (Figure 6). To estimate ET on a daily basis requires daily observations of evaporation. Since the cost of measuring evaporation each day at Wasco 8SW was prohibitive, the weekly evaporation at that station was prorated to daily amounts on the basis of daily records of evaporation observed at the USDA's Cotton Research Station.

In January 1986, the format for reporting current-year crop ET was changed. Rather than listing crop ET for each day of the previous week (7 values), average daily ET rates for the week were reported (1 value). This change was made because daily ET estimates usually did not vary greatly from day to day, or from the average daily rate over a weekly period.



Crop Water use table

CROP WATER USE—INCHES
For Week Ending July 26, 1979
—ACRE INCHES/ACRE—

Crop	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Totl Wk	Totl Mo	Prv. Mo
Alfalfa	.20	.22	.17	.20	.24	.24	.26	1.53	5.46	6.69
Cotton	.27	.29	.23	.26	.38	.32	.34	2.03	7.09	5.77
Small Grain—Harvested										
Grain Sorg	.24	.26	.20	.23	.29	.29	.31	1.82	6.40	3.17
Citrus	.14	.15	.12	.13	.17	.17	.18	1.06	3.75	4.59
Deciduous Orchard clean cultiv.	.20	.22	.17	.19	.24	.24	.26	1.52	5.40.	6.28
Deciduous Orchard with cover crop	.25	.27	.21	.24	.30	.30	.32	1.89	6.78	8.23
Vineyard	.18	.18	.15	.17	.21	.21	.22	1.33	4.63	4.86

Figure 6. Crop Water Use Table — Format Used Through 1985

CROP WATER USE TABLE

For Southern San Joaquin Valley, week ended Thursday

Acre inches of water per acre - Evapo transpiration

Crop	Average daily rate for week 1991	Normal	Forecast*	Season total 1991	Normal
Alfalfa	0.22	0.20	0.19	34.33	35.06
Dry beans	0.07	0.07	0.00	19.79	20.24
Citrus	0.15	0.14	0.13	24.41	24.78
Cotton	0.29	0.27	0.25	19.16	19.61
Deciduous orchard, with cover crop	0.26	0.25	0.23	40.73	41 38
clean cultivation	0.21	0.20	0.19	27.71	28.39
Vineyard	0.19	0.18	0.17	17.83	18.16

Forecast — For next seven days based on a normal year.
Source: Kern County Cooperative Extension. Call 837-1135 for more information.

Figure 7. Crop Water Use Table — Format Used Since 1986

Condensing the current ET data provided room to include additional important information and still maintain a concise format. The information added to the weekly reports included:

- Crop ET for the same week of a normal (average) year
- A forecast of crop ET for the next seven days
- Accumulated ET from the beginning of the current growing season
- Accumulated ET from the beginning of the growing season of a normal (average) year

An example of the revised crop water use table is shown in Figure 7. Tabulations of the ET estimates were sent to participating farm advisors each week (Figure 8).

Calculated monthly and weekly crop ET's are summarized in two ways in this report: (1) all crops for each year and (2) all years for each crop. Those summaries are presented in appendices to this report.

The summaries of calculated crop ET are grouped as follows:

1. Weekly ET for all crops for each year (Appendix A)
2. Monthly ET for all crops for each year (Appendix B)
3. Weekly ET for all years for each crop (Appendix C)
4. Monthly ET for all years for each crop (Appendix D)

Examination of those summaries shows some small differences in total ET for the same crop between the four tables. Those differences are attributable to slightly different time periods used in one series of appendix tables. Those differences are attributable to different time periods. While most of the data are tabulated on a calendar-year basis (January 1 through December 31), the summaries of weekly ET for each crop begin in late December and end in late December of the following year (Appendix C).

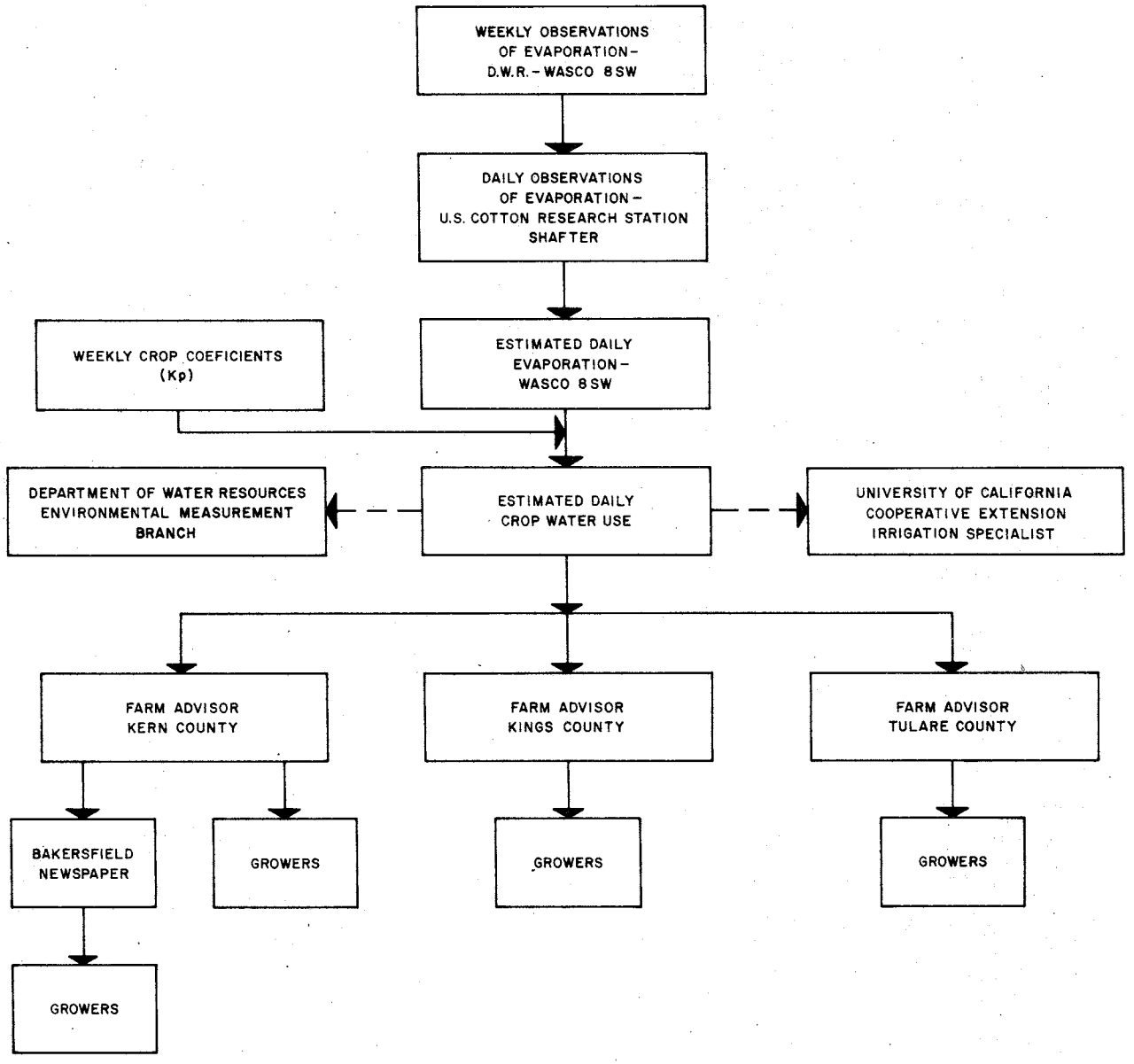


Figure 8. Calculation and Dissemination of Crop Water Use Data in the Southern San Joaquin Valley

Note: Beginning January 1986 crop ET's were estimated as averages for weekly periods thus steps 2 and 3 shown here were eliminated.

RELIABILITY OF OBSERVED EVAPORATION AND CALCULATED CROP WATER USE

Each week the calculated crop ET values were critically evaluated to assure they were reasonable before being distributed to farm advisors. To obtain a measure of the reliability of the calculated crop water use data, both observed evaporation and potential ET-alfalfa (ETP) were evaluated.

For each crop the same Kp's were used to estimate ET for a "normal" year and for a specific year. Variation in calculated ET is therefore attributable to difference in evaporation.

Comparison of Evaporation Rates

For the first four years (1977 to 1980), evaporation measured at Wasco 8SW was compared to that measured at two other locations: (1) USDA's Cotton Research Station and (2) the Fresno State/DWR station. Because of different pan environments, evaporation measured at the cotton station could not be compared directly to evaporation measured at Wasco 8SW.

Evaporation rates observed each week at the cotton station were compared to the long-term average for that location. Evaporation measured at Wasco 8SW was compared to the long-term average for Class "A" pans located in irrigated pastures on the San Joaquin Valley floor.

Percentage of "normal" evaporation at Wasco 8SW was also compared to that observed at Fresno State/DWR – about 90 miles northerly. The relationship between monthly evaporation at Wasco 8SW and the other two locations is shown for two randomly selected years. Figure 9 shows monthly evaporation for 1977 expressed as percentage of "normal" for Wasco 8SW and for the cotton station. A similar plotting for Bakersfield 10NW and Fresno State/DWR is shown for 1982 in Figure 10.

Table 3 lists evaporation as percentage of "normal" for Wasco 8SW, the cotton station, and Fresno State/DWR. Those percentages are for the principal growing season (March to October) and for the entire year.

Beginning in 1983, evaporation from DWR's agroclimatic stations was compared to average evaporation from five other sites in the Valley. Locations of those sites are shown in Figure 1. Evaporation, as a percentage of the five-station average, is presented in Table 4.

Evaporation observed at DWR's agroclimatic sites located near Bakersfield was considered to be a reliable basis for estimating ET for the selected crops.

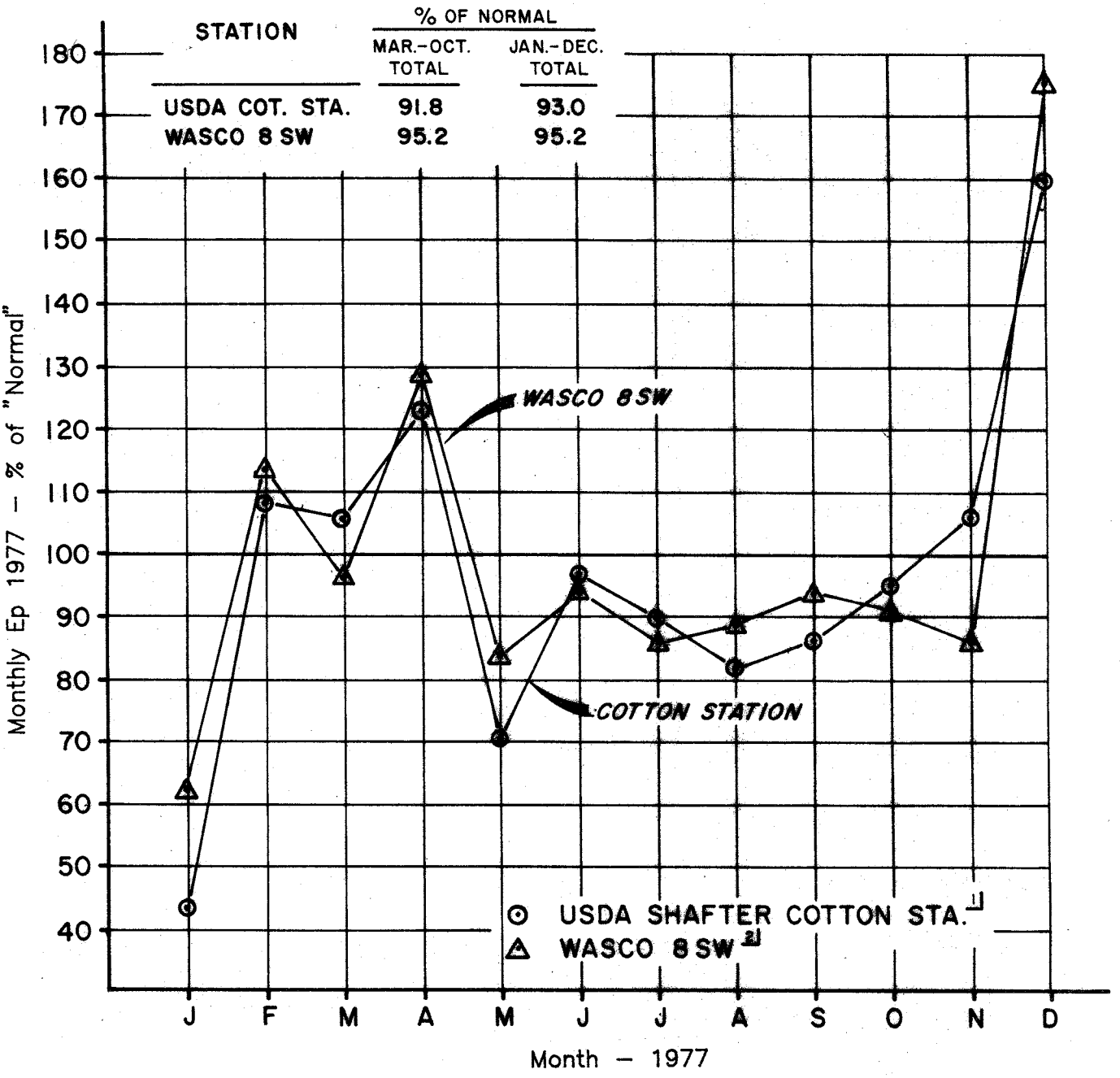


Figure 9. 1977 Monthly Ep as Percentage of "Normal" for USDA Cotton Sta. – Shafter (Semi–Dryland) 1/ and Wasco 8SW (Irrigated Pasture) 2/

1/ 1977 obs. monthly Ep, Cotton Sta. compared to long term "normal" for that station.

2/ 1977 monthly Ep, Wasco 8SW compared to long term average for pasture pans in San Joaquin Valley – Table 1, Bul. 113–3.

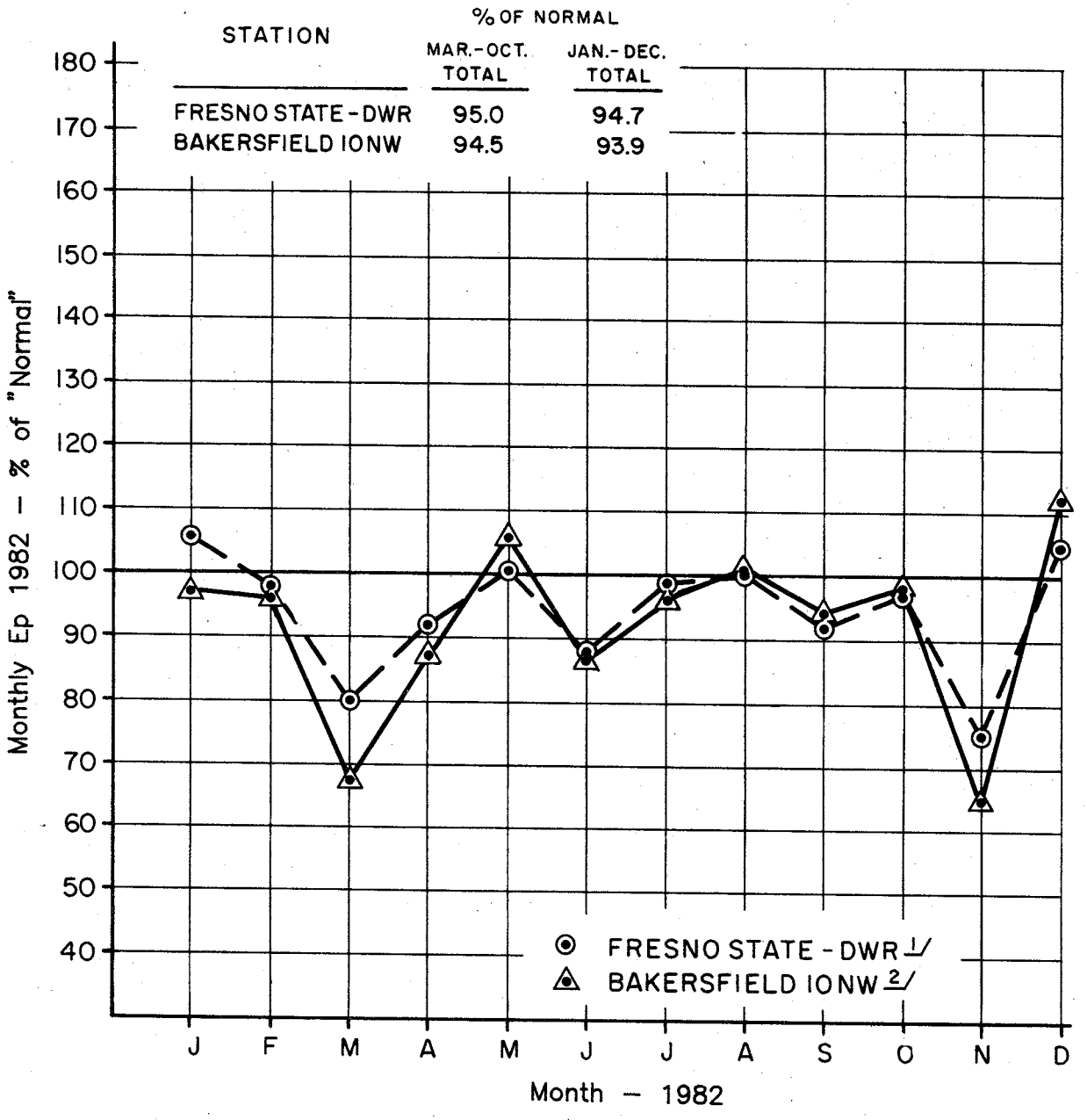


Figure 10. 1982 Monthly Ep as a Percentage of "Normal" for Fresno State – DWR (Irrigated Pasture) 1/ and Bakersfield 10NW (Irrigated Pasture) 2/

1/ 1982 obs. monthly Ep, Fresno State – DWR comared to long term "normal" for that station.

2/ 1982 obs. monthly Ep, Bakersfield 10NW compared to long term average for pasture pans in the San Joaquin Valley.

TABLE 3

MEASURED EVAPORATION AS A PERCENTAGE OF LONG-TERM AVERAGE FOR THREE LOCATIONS IN SOUTHERN SAN JOAQUIN VALLEY

Year	Evaporation Mar – Oct			Evaporation Jan – Dec		
	Near Bakersfield[1]	USDA Cotton Station	Fresno State/DWR	Near Bakersfield[1]	USDA Cotton Station	Fresno State/DWR
	Percentage of Normal					
1977	95	92	96	95	93	97
1978	86	88	91	85	87	90
1979	95	90	100	97	90	101
1980	93	90	98	94	87	98
1981	107	91	107	108	91	106
1982	94	80	94	94	80	94

[1]1977 – 1980; Wasco 8SW.
1981 – 1982; Bakersfield 10NW.

TABLE 4

EVAPORATION MEASURED NEAR BAKERSFIELD AS A PERCENTAGE OF AVERAGE FOR SOUTHERN SAN JOAQUIN VALLEY[1]

Year	Evaporation Mar – Oct		Evaporation Jan – Dec	
	Inches	Percentage of Area Average	Inches	Percentage of Area Average
1983	56.91	100	63.29	100
1984	62.44	98	70.46	99
1985	60.11	99	66.54	100
1986	62.11	102	69.77	103
1987	62.72	103	70.44	104
1988	60.34	97	68.57	98
1989	58.91	94	66.42	96
1990	56.47	89	63.91	90
1991	57.33	93	65.03	92

[1]Area average evaporation for southern San Joaquin Valley is from measurements at five locations: Wheeler Ridge – Maricopa Water Storage District – Greenlee; USDA Cotton Research Station; University of California Kearney Field Station; Dudley Ridge Farms; Fresno State/DWR.

Comparison of Potential ET-Alfalfa (ETP)

Potential Et-alfalfa (ETP) is the ET rate of vigorously growing alfalfa at full ground cover and with soil moisture not limiting. ETP is the Jensen-Haise reference crop. ETP, calculated as 0.92 Ep, is shown for weekly periods in Appendix Tables A and C. ETP summarized into monthly amounts is shown in Appendix Tables B and D.

Figure 11 shows ETP for a "normal" year in the southern San Joaquin Valley, estimated by three methods: (1) The curve identified as "calculated ETP (Penman)" was calculated using a modified Penman equation from solar radiation, air temperature, humidity, and wind data collected once each day within 14 miles of Wasco 8SW,[1] (2) weekly ETP calculated as 0.92 x measured evaporation, and (3) measured of ET of grass x 1.15. Similar examples for two specific years (1977 and 1982) are presented in Figures 12 and 13.

ETP calculated using the Penman equation was available for ten years, 1977 to 1986. A summary of that monthly ETP data is presented in Table 5.

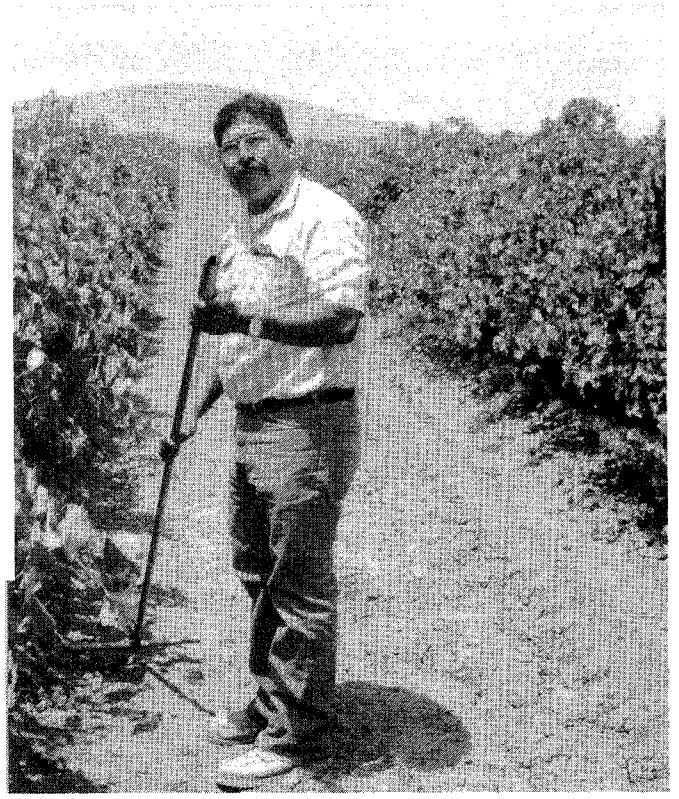
Figure 14 shows the linear relationship between the ETP (Penman) data and ETP estimated from measured evaporation for weekly periods.

Field Performance

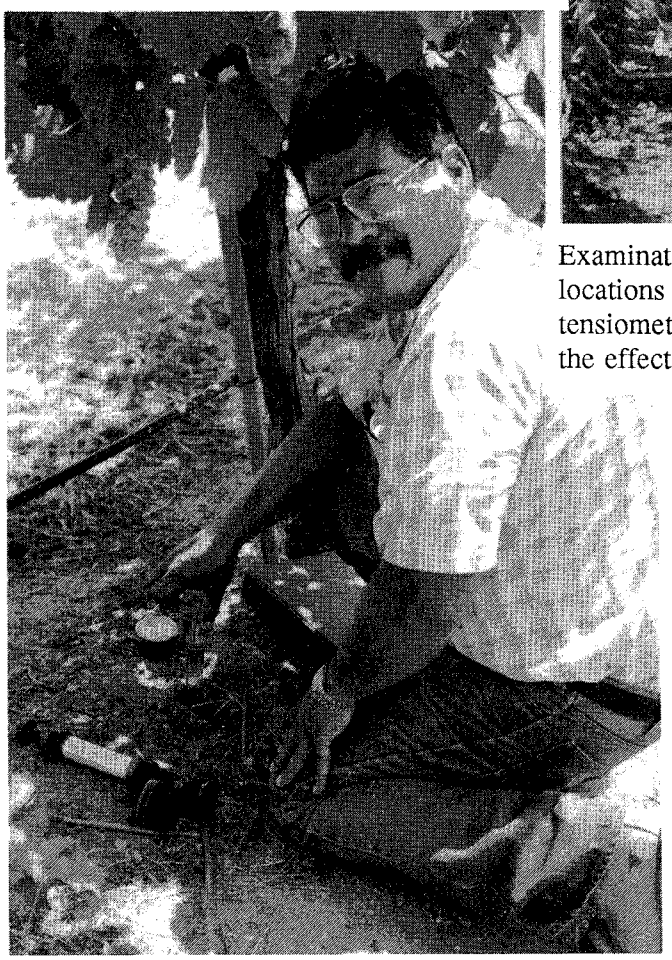
The best appraisal of the crop water use estimates is their effectiveness in commercial agricultural production.

One professional irrigation advisor, Jacinto Gonzalez, President, Aguabono Company in Porterville, has independently demonstrated the calculated ET values to be reliable under actual field conditions. For several years he carefully compared calculated irrigation requirements, water actually applied, and corresponding changes in soil moisture levels. He observed that when irrigation water was less than the calculated requirement, soil moisture decreased and excess irrigations resulted in increased soil moisture. His observations indicate that the calculated crop water use values are very close to actual moisture use. These San Joaquin Valley fields were irrigated with calibrated drip and minisprinkler systems. Water applied was measured with propeller-type meters. Soil moisture was monitored with tensiometers at fixed field locations and with soil samples augured from other random locations. The crops irrigated included vineyard, citrus, almonds, peaches, and plums. Both crop yield and quality were enhanced with the improved irrigation management.

[1]These ETP estimates were calculated by Superior Farming Company staff for their in-house irrigation management activity.



Examination of soil samples augered from random locations in the field is recommended to supplement tensiometer data. Such examinations provide a check on the effectiveness of ET-based irrigation schedules.



Tensiometers provide fast and reliable monitoring of actual soil moisture status. Instruments are usually installed to three or four depths at each fixed location in the field.

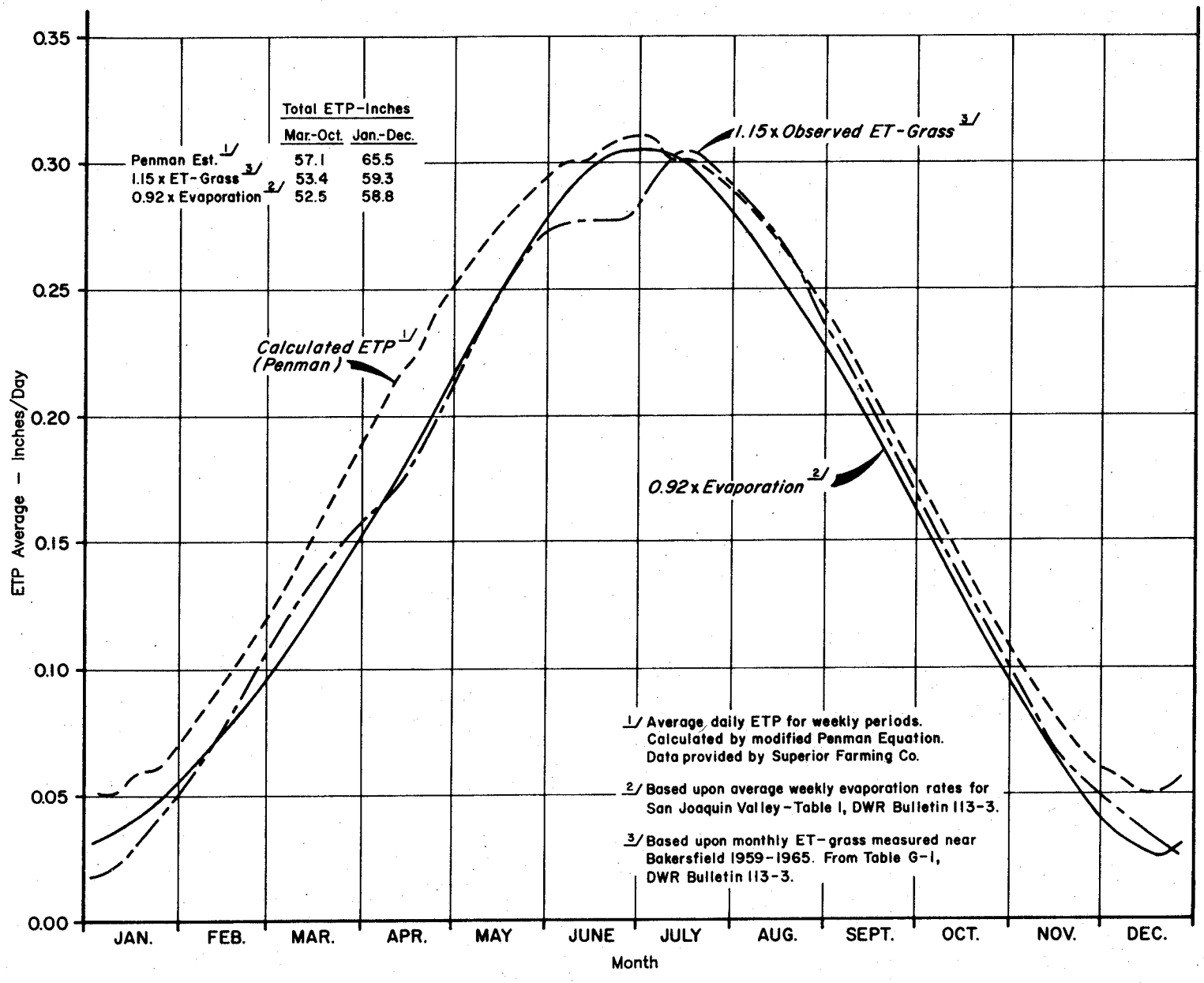


Figure 11. Calculated Normal ETP (ET – Alfalfa) for Southern San Joaquin Valley

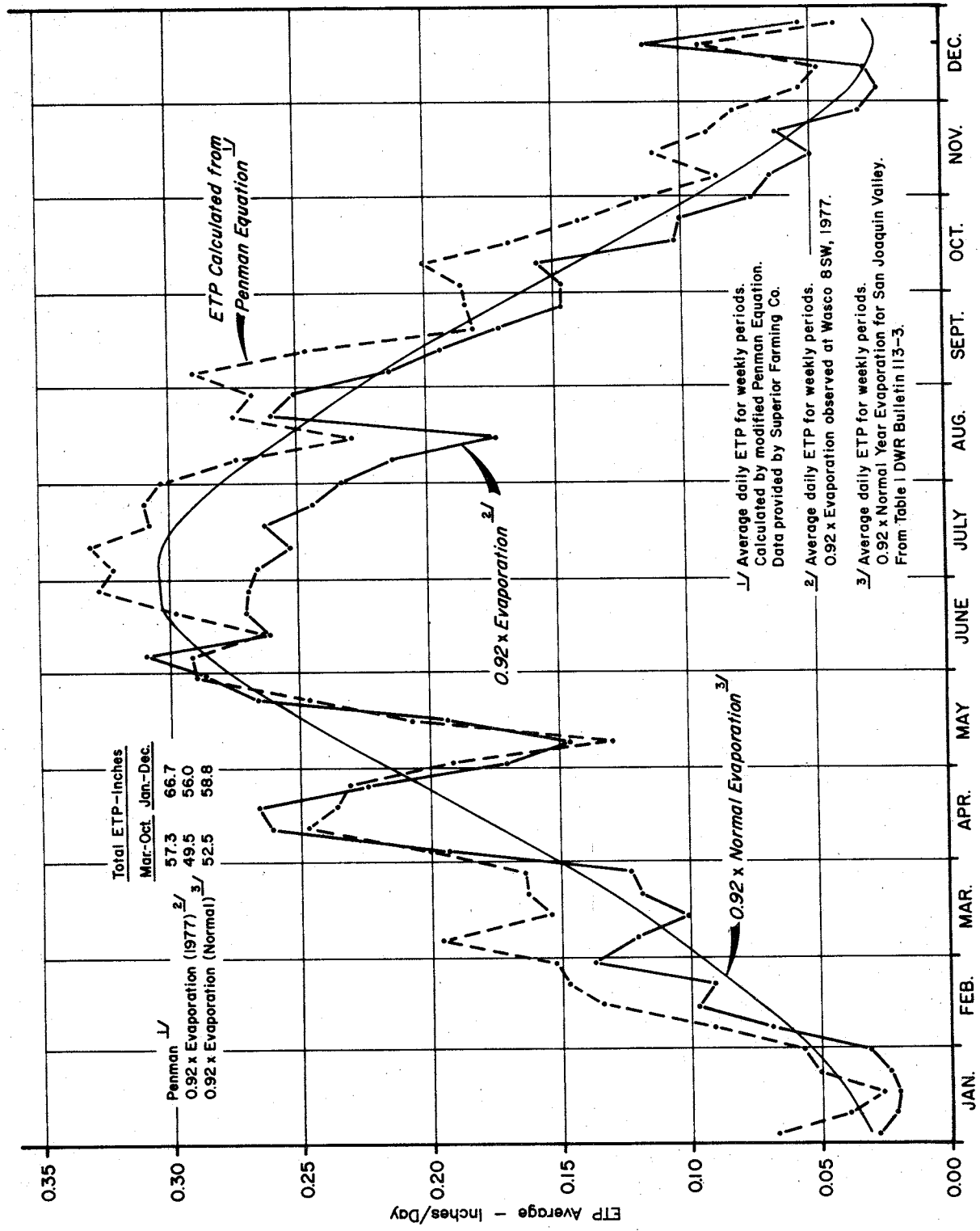


Figure 12. Calculated ETP (ET - Alfalfa) for Southern San Joaquin Valley - 1977

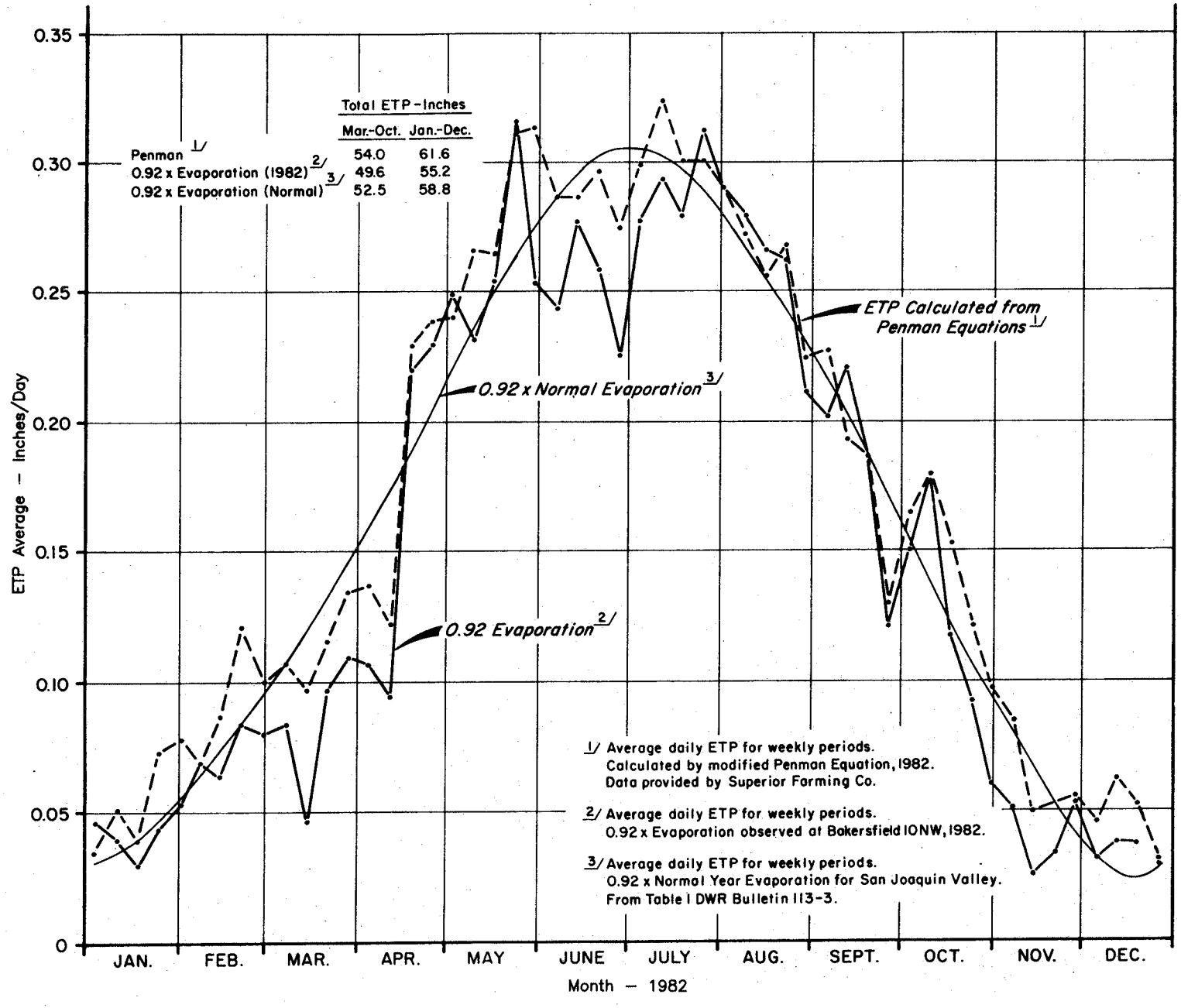


Figure 13. Calculated ETP (ET – Alfalfa) for Southern San Joaquin Valley – 1982

TABLE 5

SUMMARY OF MONTHLY RATES OF EVAPOTRANSPIRATION POTENTIAL – ETP
CALCULATED USING MODIFIED PENMAN EQUATION[1]
(inches)

Month	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	Mean	Std. Dev.	Std. Error
JAN	1.10	1.68	1.74	1.56	2.03	1.72	1.60	1.92	1.72	2.13	1.72	0.27	0.09
FEB	3.35	2.20	2.31	2.94	2.34	2.58	2.66	3.20	3.06	2.63	2.73	0.37	0.12
MAR	5.25	3.67	3.66	4.40	3.56	3.54	4.04	5.11	4.12	4.09	4.14	0.58	0.18
APR	6.76	4.97	6.32	5.81	5.93	5.40	5.82	5.80	6.37	6.22	5.94	0.49	0.16
MAY	6.92	8.38	9.14	7.76	8.04	8.64	7.80	9.10	7.95	8.60	8.23	0.64	0.20
JUN	9.00	8.93	9.75	8.65	8.81	8.68	9.17	9.06	9.39	9.22	9.07	0.32	0.10
JUL	9.65	9.32	9.18	8.73	8.84	9.28	9.04	9.42	9.62	8.79	9.19	0.31	0.10
AUG	8.25	8.46	8.02	7.82	8.46	8.26	7.83	8.22	8.51	8.12	8.20	0.24	0.08
SEP	6.76	5.94	6.78	6.20	6.36	5.49	6.55	6.98	5.49	5.98	6.25	0.50	0.16
OCT	4.98	5.38	4.60	5.10	4.78	4.71	4.53	4.27	4.98	4.80	4.81	0.30	0.09
NOV	2.82	2.48	2.80	2.74	2.98	1.92	2.34	2.58	2.51	3.23	2.64	0.34	0.11
DEC	1.66	1.21	2.34	1.62	1.54	1.51	1.56	1.57	1.36	1.63	1.60	0.28	0.09
MAR-OCT TOTAL	57.57	55.05	57.45	54.47	54.78	54.00	54.78	57.96	56.43	55.82	55.83	1.36	0.43
JAN-DEC TOTAL	66.50	62.62	66.64	63.33	63.67	61.73	62.94	67.23	65.08	65.44	64.52	1.82	0.58

[1]Calculated from meterological data by Superior Farming Company in Bakersfield area.

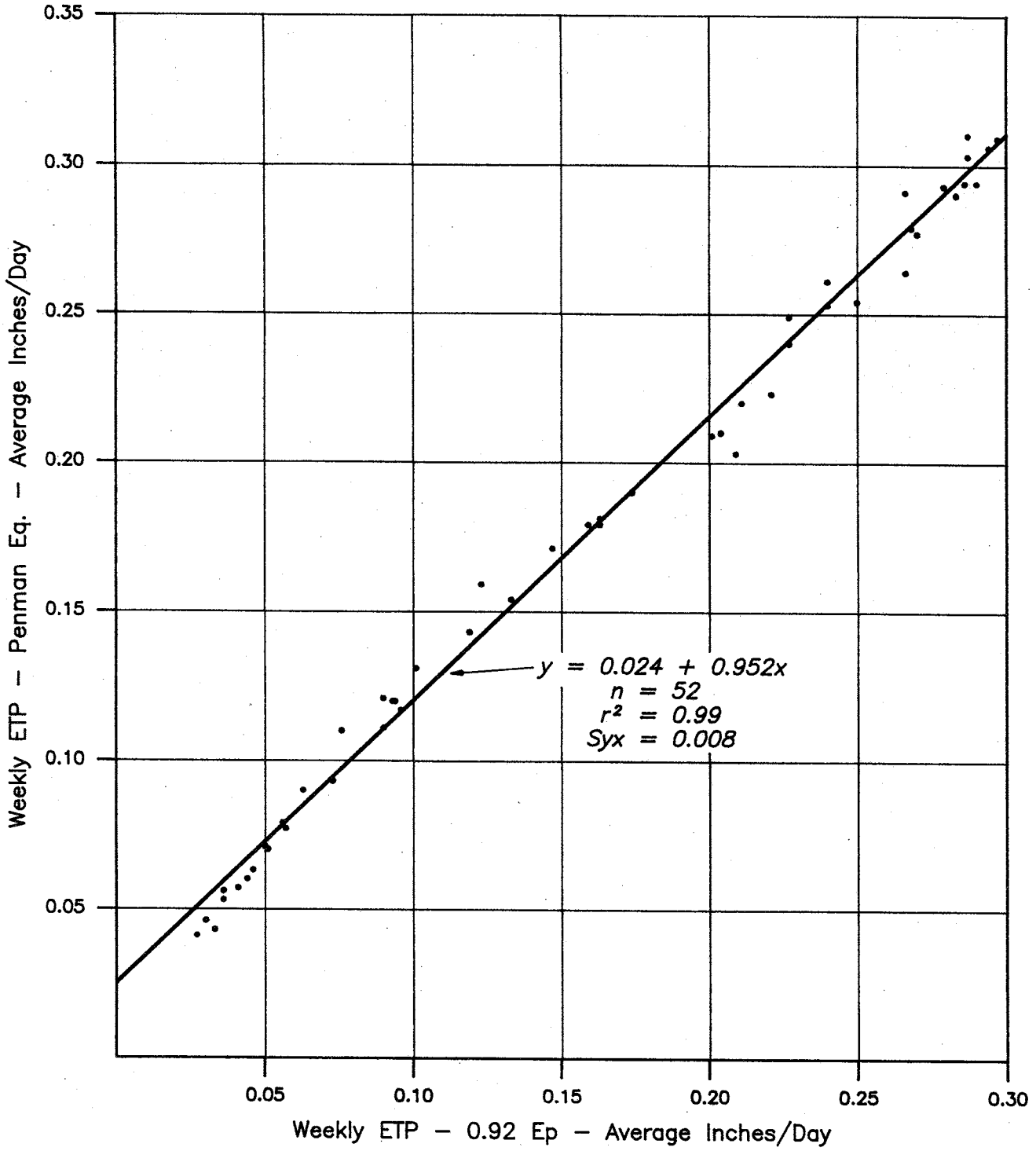


Figure 14. Relationship Between Average Weekly ETP Calculated as 0.92 x Class "A" Pan Evaporation (x) and Calculated with Penman Equation (y) – Bakersfield Area Weekly Averages for 1977 to 1986

Scheduling Irrigations with ET Data

The calculated crop water use data are intended to be used as guides for scheduling irrigations – to supplement but not replace monitoring of actual soil moisture.

For those crops irrigated at frequent intervals by drip, mister, or microsprinkler irrigation, the required hours of operation can be determined from the current rate of water use and the measured or estimated application efficiency of the system. For surface irrigation – furrows, borders, and movable sprinklers – irrigations are usually scheduled when about half the moisture stored in the soil has been depleted. Yet, with knowledge of current water use rates, irrigation dates and amounts of water applied may be varied to accommodate other necessary cultural operations such as weed and insect control. Farm advisors can provide growers with information on application efficiencies for various types of irrigation systems, as well as amounts of available moisture storage for specific crops and soils.